

Package ‘pems.utils’

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Type Package

Title Portable Emissions (and Other Mobile) Measurement System
Utilities

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URL <http://pems.r-forge.r-project.org/>

Description Utility functions for the handling, analysis and visualisation of data from portable emissions measurement systems ('PEMS') and other similar mobile activity monitoring devices. The package includes a dedicated 'pems' data class that manages many of the quality control, unit handling and data archiving issues that can hinder efforts to standardise 'PEMS' research.

Depends R (>= 2.10.0), lattice, loa

Imports methods, utils, grid, RColorBrewer, latticeExtra, baseline,
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pems.utils-package *pems.utils*

Description

The R package `pems.utils` contains a range of functions for the routine handling and analysis of data collected by portable emissions measurement systems (PEMS) and other similar mobile monitoring systems.

Details

```

Package:  pems.utils
Type:    Package
Version:  0.2.26.4
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License:  GPL (>= 2)
LazyLoad: yes

```

The `pems.utils` functions have been arranged according to usage, as follows:

1. Getting data in and out of `pems.utils`.

- 1.1. Functions for making and importing datasets for use with `pems.utils`: [pems](#), [import2PEMS](#), etc.
- 1.2. Exporting data from pems objects and R: [export.data](#).
2. Data Structure and General Handling
 - 2.1. The pems object structure: [pems.structure](#), [getPEMSElement](#), [pemsData](#), etc.
 - 2.2. Generic pems handling
 - 2.2.1. pems objects, [pems.generics](#).
 - 2.2.2. pems.element objects, [pems.element.generics](#).
 - 2.3. Structure Handling
 - 2.3.1. Merging pems objects: [merge.pems](#), [align](#), etc.
 - 2.3.2. Conditioning pems objects: [conditioning.pems.data](#), [cutBy](#), etc.
 - 2.3.3. Time handling functions: [regularize](#), etc.
 - 2.3.4. Unit handler functions: [getUnits](#), [setUnits](#), [convertUnits](#), etc.
3. pems Data Handling
 - 3.1. Calculations
 - 3.1.1. Common calculations: [common.calculations](#), [calcDistance](#), [calcAccel](#), etc.
 - 3.1.2. VSP calculations: [calcVSP](#), etc.
 - 3.1.3. Emissions calculations: [calcEm](#), etc.
 - 3.2. Analysing data in pems objects: [summary.reports](#)
 - 3.3. Plots for pems objects: [pems.plots](#), [latticePlot](#), [pemsPlot](#), etc.
4. Reference datasets, examples, look-up tables, etc.
 - 4.1. Example datasets: [pems.1](#).
 - 4.2. look-up tables: [ref.unit.conversions](#), etc.
5. Other Code
 - 5.1. Misc
 - 5.1.1. Common [check...](#) functions for the routine handling of function arguments/user inputs.
 - 5.1.2. Other correction code
 - 5.2. Tidyverse related code... [pems.tidyverse](#)

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References

Functions in `pems.utils` make extensive use of code developed by others. In particular, I gratefully acknowledge the huge contributions of the R Core Team and numerous contributors in developing and maintaining R:

R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org/>.

See Also

[pems](#), [import2PEMS](#)

1.1.make.import.data *making and importing data*

Description

Various pems.utils functions to make and import data as pems objects.

Usage

```
#making pems objects

is.pems(x, full.test = TRUE, ...)

pems(x, units = NULL, constants = NULL, history = NULL,
     ...)

pems.element(x, name = NULL, units = NULL,
            ...)

#associated

isPEMS(...)
makePEMS(...)
makePEMSElement(...)
rebuildPEMS(x, ...)

## S3 method for class 'data.frame'
as.pems(x, ...)

#importing data as pems objects

#general

import2PEMS(file.name = file.choose(), ..., file.reader = read.delim,
            output="pems")

importTAB2PEMS(..., file.reader = read.delim)

importCSV2PEMS(..., file.reader = read.csv)
```

```

#Horiba OBS

importOBS2PEMS(file.name = file.choose(), pems = "Horiba OBS",
               constants = NULL, history = NULL,
               analytes = c("co", "co2", "nox", "hc"),
               fuel = c("petrol", "diesel", "gasoline"), ...)

importOB12PEMS(file.name = file.choose(), pems = "Horiba OBS",
               constants = NULL, history = NULL,
               analytes = c("co", "co2", "nox", "hc"),
               fuel = c("petrol", "diesel", "gasoline"), ...)

#3DATX parSYNC

importParSYNC2PEMS(file.name = file.choose(), reset.signals = TRUE,
                   history = NULL, constants = NULL, pm.analyzer = "parSYNC",
                   ... )

#3DATX CAGE
importCAGE2PEMS(..., calibrator = "CAGE")

#Sensors Inc SEMTECH

importSEMTECH2PEMS(file.name = file.choose(), history = NULL,
                   constants = NULL, pems = "SEMTECH", ...)

#RoyalTek GPS

importRoyalTek2PEMS(file.name = file.choose(),
                   file.type = c("special", "txt", "nmea"),
                   vbox = "RoyalTEK", history = NULL, constants = NULL, ...)

#KML files

importKML2PEMS(file.name = file.choose(), history = NULL,
               constants = NULL, source = "Unknown", ...)

```

Arguments

x (A required object) For `is.pems`, any object to be tested as a pems object. For `pems`, an object to be used as the starting point to make a pems object, so typically a `data.frame` or another pems object. For `pems.element`, an object to be

	used as the starting point to make a <code>pems.element</code> . For <code>rebuildPEMS</code> , a <code>pems</code> object to be rebuilt.
<code>full.test</code>	(Logical) For <code>is.pems</code> , should the full <code>pems</code> test be applied and the <code>pems</code> structure confirmed?
<code>...</code>	(Optional) Other arguments, handling varies. For <code>is.pems</code> these are ignored. For <code>pems</code> these are added to the <code>pems</code> object unmodified. For <code>import...</code> functions, these are passed on and added to the <code>constants</code> component of the <code>pems</code> object. Note: This different handling is experimental and may be subject to change in future.
<code>units, constants, history</code>	(Default <code>pems</code> arguments) These are arguments that are routinely generated for <code>pems</code> objects. <code>units</code> holds unit ids for unit management, <code>constants</code> holds constants that should used specifically with data in the <code>pems</code> object, and <code>history</code> holds the <code>pems</code> object modification history.
<code>name</code>	(Default <code>pems.element</code> argument) <code>name</code> (and <code>units</code>) are arguments that are routinely generated for <code>pems.element</code> objects.
<code>file.name</code>	(file connection, etc.) For <code>import...</code> functions, the file/source to be imported. Note: the default, <code>file.name = file.choose()</code> , automatically opens a file browser if this argument is not supplied.
<code>file.type, file.reader</code>	Data reader parameters for some <code>import...</code> functions. <code>file.type</code> is the type of file to be imported. Note: Some <code>import...</code> functions can handle more than one file type, and <code>file.type = "[option]"</code> should be used to identify these. (Note: <code>file.type</code> options are typically file type identifiers, such as the file extensions, and a default 'special', which leaves the choice to the function. This way this option can typically be ignored unless, e.g. the function does not recognise the file type but the user knows it and wants to force the method.) <code>file.reader</code> identifies the R method/function that should be used to read data from the supplied file. For example, for <code>importTAB2PEMS</code> and <code>importCSV2PEMS</code> , by default, these are the standard R <code>read...</code> functions <code>read.delim</code> and <code>read.csv</code> , respectively.
<code>output</code>	Where included in formal arguments, an option to control function output.
<code>pems, vbox, pm.analyzer, calibrator, source</code>	(Character vectors) For some <code>import...</code> functions, data source descriptions may be automatically added to the <code>pems</code> object. <code>pems</code> and <code>vbox</code> are two examples, but others, such as <code>vehicle</code> and <code>fuel</code> descriptions can also be added in a similar fashion. Note: These are for user-reference, so can say whatever you want.
<code>analytes</code>	(Character vector) For <code>import...</code> functions, the names of any <code>pems</code> elements to be tagged as analyte concentrations. Note: If the PEMS unit reports concentrations rather than emissions it is often useful to identify these at import to avoid confusion, and to simplify later handling. So, if encountered, analyte names are prefixed with the term 'conc. '.
<code>fuel</code>	Some <code>import...</code> functions that handle exhaust monitoring system data may assume fuel types when calibrating inputs or calculating constants. In such cases the <code>fuel</code> argument is also included to identify which fuel was used.

`reset.signals` (Logical or Character vector) For `importParSYNC2PEMS`, should any raw signal be reset? The default (TRUE) reverses the sign of opacity and ionization signals.

Details

`is.pems` tests if an object is/is not a pems object.

`pems` makes a pems object using supplied data and information.

`pems.element` makes a `pems.element` object using supplied data and information.

`as.pems...` functions attempt to convert a supplied object into a pems object. Currently, there is only a `data.frame` method and (by default) a `pems` method.

`isPEMS`, `makePEMS` and `makePEMSElement` are historical code, retained for backward compatibility.

`rebuildPEMS` rebuilds pems object as a different build version.

Crude `import...` functions import simple file structures, and are useful for getting data quickly into R: `pems.utils.importTAB2PEMS` imports tab delimited files and clipboard content. `importCSV2PEMS` imports comma delimited files. Both assume a simple file structure (i.e. data series in columns with names as headers), but require some time data management by the user. Note: These are wrappers for `import2PEMS`.

Other `import...` import specific file types.

`importOBS2PEMS` imports standard Horiba OBS files and converts them to pems objects. See Notes below.

`importOB12PEMS` imports `.OB1` files and converts them to pems objects. `OB1` files are generated by a Visual Basic PEMS data handler used during the RETEMM project. Notes below.

`importParSYNC2PEMS` imports standard `parSYNC` files and converts them to pems objects. See Notes below.

`importCAGE2PEMS` imports standard `CAGE` files and converts them to pems objects. See `importParSYNC2PEMS` Notes below.

`importSEMTECH2PEMS` imports Sensors Inc. SEMTECH ECOSTAR files and converts them to pems objects. See Notes below.

`importRoyalTek2PEMS` imports `.txt` and `.nmea` format Royal Tek GPS files and converts them to pems objects. See Notes below.

`importKML2PEMS` imports `.kml` format KML files and converts them to pems objects. See Notes below.

Value

`is.pems` return a logical, TRUE if the supplied object is pems class, otherwise FALSE. If the argument `full.test = TRUE` is also supplied, additional information about the object is returned as `comment(output)`.

`pems` and `pems.element` functions return pems and `pems.element` objects, respectively, made using the supplied file and any additional information also supplied in the same call.

`rebuildPEMS` rebuilds the supplied pems object. The default rebuilds as the latest build structure.

`import...` functions return a pems object, made using the supplied file and any additional information also supplied in the same call.

Note

`isPEMS`, `makePEMS` and `makePEMSElement` were earlier functions that performed the same functions as `is.pems`, `pems` and `pems.elements`, respectively. The the current versions of these functions are wrappers for their replacements.

With the crude `import...` functions (`import2PEMS`, `importTAB2PEMS`, `importCSV2PEMS`) modifications are minimal. Unless any additional changes are requested in the `import...(...)` call, the data is simply read in as a `data.frame` and converted to a `pems` object.

With `importOBS2PEMS`, OBS data is also modified as follows: data series names are simplified and converted to lower case to simplify use in R; the data series `time.stamp` and `local.time` are added (generated using the file time stamp, the row counter and the `log.rate` constant); data series latitude and longitude are resigned according to set N/S and E/W values, if these are present/valid; latitude and longitude units are also reset to 'd.degLat' and 'd.degLon'. Any data series names in `analytes` is renamed 'conc.[analyte name]'. If not supplied in the `importOBS2PEMS`, typical OBS constants are currently assumed. Several of these are based on emission source fuel. Defaults for these are generated according to fuel (default 'petrol').

With `importOB12PEMS`, handling is similar to that with `importOBS2PEMS`.

With `importParSYNC2PEMS`, the `parSYNC` data modifications are as follows: `parSYNC` Date and Time data-series are merged and converted into *POSIX as `time.stamp`; `local.time` is calculated from this; the `parSYNC` data series `Timestamp` is retained as `parsync.timestamp`; by default units are removed from data-series names, but retained as `units(pems)`; (again by default) all names are converted to lower case. The default option `reset.signal = TRUE` reverses the voltage reading of opacity and ionization time-series ($x = -x$), if present. Alternatively, imports can be identified specifically by name, e.g. `reset.signal = "opacity"` to just reset opacity. Typical OBS constants are currently assumed, if not supplied. Several of these are based on emission source fuel. The default assumption is that the fuel is 'petrol' unless fuel has been assigned.

With `importCAGE2PEMS`, handling is similar to that with `importParSYNC2PEMS`.

With `importSEMTECH2PEMS`, SEMTECH data is imported and modified as follows: data series names are simplified and converted to lower case to simplify use in R; the data series `time.stamp` and `local.time` are added (generated using the file time stamp). Defaults constants are assigned according to fuel (default 'petrol'). This function is in-development and has so far only been used with files from two sources, so handle with care, and `time.format` has varied so may need resetting for some files.

With `importRoyalTek2PEMS`, the Royal Tek data modifications are currently being documented.

With `importKML2PEMS`, the function attempts to import and `time.stamp`, latitude, longtiude and altitude data in the supplied KML file. This function is in-development and has so far only been used with KML files from one source, so handle with care.

Author(s)

Karl Ropkins

References

References in preparation.

See Also

See [ref.unit.conversions](#) and [convertUnits](#) for general unit handling; [merge.pems](#) for pems data merging and alignment.

Examples

```
#####
##example 1
#####

#make little pems

data <- data.frame(speed=1:10, emissions=1:10)
units <- c("m/s", "g/s")
pems <- pems(x = data, units=units, example="my record")

pems                #the pems object
summary(pems)       #summary of held data
pems$speed          #the speed pems.element

#import data file as pems using import... functions

#For example, to import CSV file as pems object
## Not run:
pems <- importCSV2PEMS()

## End(Not run)
```

1.2.export.data

exporting PEMS data

Description

Some functions for exporting data from R and pems.utils.

Usage

```
exportPEMSData(data, file="tempfile", ...,
               sep="\t", file.writer = write.table,
               row.names = FALSE)

exportPEMS2CSV(pems, file="tempfile", ...)

#exportPEMS2Excel
#currently disabled
```

Arguments

<code>data</code> , <code>pems</code>	(A required object) The object to export from R, typically a <code>data.frame</code> or <code>pems</code> object.
<code>file</code>	(Character) The name of the file to create when exporting data. This can be 'clipboard', to export to the clipboard assuming the clipboard buffers are not exceeded.
<code>...</code>	(Optional) Other arguments, handling varies. For <code>export...</code> functions, these are currently ignored. Note: This and may be subject to change in future.
<code>sep</code> , <code>file.writer</code> , <code>row.names</code>	(Various arguments) <code>file.writer</code> is the R function used to create the export file. <code>sep</code> and <code>row.names</code> are arguments passed to <code>file.writer</code> .

Details

Both `exportPEMSData` and `exportPEMS2CSV` export the data component of a supplied `pems` object. `exportPEMSData` saves it as a tab-delimited `.txt` file. `exportPEMS2CSV` saves it as a comma-delimited `.csv` file. See below.

Value

By default, `exportPEMSData` and `exportPEMS2CSV`, respectively, generate tab-delimited and comma-delimited file copies of the data element of the supplied data.

If a file name is not set using the `file` argument, the is named `tempfile`.

`exportPEMS2CSV` modified the data as part of export as follows: It adds the time-series units to the time.series name in form `[name]_[units]`.

Warning

Currently, the `export...` functions overwrite without warnings.

Note

`exportPEMS2Excel` is curenly disabled.

These are very crude functions in the most part because they are rarely used. Suggestions for helpful improvements would be very welcome.

Author(s)

Karl Ropkins

References

References in preparation.

See Also

See [import2PEMS](#), etc. for importing data into `pems.utils`.

Examples

```
#####  
##example 1  
#####  
  
#making a tab-delimited copy of pems.1  
  
## Not run:  
exportPEMSData(pems.1, "pems.example.txt")  
dir()  
  
## End(Not run)
```

2.2.1.generic.pems.handlers*Generic handling of pems objects*

Description

pems objects can be manipulated using generic functions like print, plot and summary in a similar fashion to objects of other R classes.

Usage

```
## S3 method for class 'pems'  
as.data.frame(x,...)  
  
## S3 method for class 'pems'  
dim(x, ...)  
  
## S3 method for class 'pems'  
x$name, ...  
  
## S3 replacement method for class 'pems'  
x$name, ... <- value  
  
## S3 method for class 'pems'  
x[i, j, ..., force = FALSE, simplify = TRUE]  
  
## S3 replacement method for class 'pems'  
x[i, j, ..., force = FALSE] <- value  
  
## S3 method for class 'pems'  
x[[k, ...]]
```

```

## S3 replacement method for class 'pems'
x[[k, ...]] <- value

## S3 method for class 'pems'
with(data, expr, ...)

## S3 method for class 'pems'
subset(x, ...)

## S3 method for class 'pems'
names(x, ...)

## S3 replacement method for class 'pems'
names(x, ...) <- value

## S3 method for class 'pems'
print(x,..., rows=NULL, cols=NULL, width=NULL)

## S3 method for class 'pems'
plot(x, id = NULL, ignore = "time.stamp", n = 3, ...)

## S3 method for class 'pems'
head(x, n = 6, ...)

## S3 method for class 'pems'
tail(x, n = 6, ...)

## S3 method for class 'pems'
summary(object, ...)

## S3 method for class 'pems'
na.omit(object, ...)

## S3 method for class 'pems'
units(x)

## S3 replacement method for class 'pems'
units(x) <- value

```

Arguments

x, object, data	(An Object of pems class). For direct use with print, plot, summary, etc. NOTE: Object naming (i.e., x or object) is determined in parent or base function in R, so naming can vary by method.
name	Element name, which operates in a similar fashion to data.frame names, e.g. pems\$name extracts the element name from the pems object pems.

<code>i, j</code>	Row and column (elements) indices, which operate as a stricter version of <code>data.frame</code> indices. See Note below.
<code>k</code>	Structural indices. See Note below.
<code>expr</code>	(Expression) For <code>with(pems)</code> , an expression to be evaluated inside the supplied <code>pems</code> object.
<code>value</code>	(vector, <code>data.frame</code> or <code>pems</code>) An object to be inserted into a <code>pems</code> object in e.g. the form <code>pems[i, j] <- value</code> or <code>pems\$name <- value</code> .
<code>...</code>	Addition options, typically passed to associated default method(s).
<code>force</code>	(Logical or character) Data element handling options. <code>force</code> provides various options to forces data to fit it destination. This can either be set as a logical (TRUE/FALSE <code>force/don't force</code>) or one or more character strings to specify particular types of forcing to try when e.g. fitting <code>value</code> into <code>pems[i, j]</code> : <code>'omit.err.cases'</code> , equivalent to TRUE, remove any unknown/unfound <code>i</code> or <code>j</code> terms; <code>'na.pad.insert'</code> expand the <code>value</code> to fit larger <code>pems[i, j]</code> , placing NAs in any holes generated; <code>'na.pad.target'</code> like previous but expanding <code>pems[i, j]</code> to fit larger <code>value</code> ; <code>'fill.insert'</code> like <code>'na.pad.inert'</code> but holes are filled by wrapping the supplied <code>value</code> within elements and then by element.
<code>simplify</code>	(Logical) <code>simplify</code> returns a <code>pems.element</code> rather than a <code>pems</code> object if possible.
<code>id, ignore</code>	(local plot parameters). <code>id</code> identifies which data series to plot; <code>ignore</code> identifies which data series to ignore when leaving the choice of <code>id</code> to the function; and, <code>n</code> gives the maximum number of data series to plot when leaving the choice of <code>id</code> to the function.
<code>rows, cols, width</code>	(numerics, optional). For <code>print</code> , if supplied, these reset the number of rows and columns to table when printing a <code>pems</code> object, and character <code>width</code> to print across.
<code>n</code>	(various). For <code>plot</code> , sets the maximum number of data series to plot when leaving the choice of <code>id</code> to the function. For <code>head</code> or <code>tail</code> , sets the number of rows.

Value

Generic functions provide appropriate (conventional) handling of objects of `'pems'` class:

`as.data.frame(pems)` extracts the `data.frame` component of a `pems` object.

`dim(pems)` extracts the dimensions, row count and column count, respectively, of the `data.frame` component of a `pems` object. The function also allows `nrow(pems)` and `ncol(pems)`.

`pems$name` extracts the named element from a `pems` objects in a similar fashion to `data.frame$name`. Likewise, `pems$name <- value` inserts `value` into a `pems` objects in a similar fashion to `data.frame$name <- value`.

`pems.object[i, j]` extracts the `[i,j]` elements of the data held in a `pems` object. This is returned as either a `pems` or `pems.element` object depending on the dimension of the extracted data and the `simplify` setting.

`pems.object[i, j]<- insert value` into the `[i,j]` region of the supplied `pems` object. By default this action is strict and mismatching `pems[i, j]` and `value` dimension produce an error, although mismatching insertions may be forced using the `force` argument.

`pems.object[[k]]` extracts structural elements of a pems object: `data`, the `data.frame`; units the unit table, etc.

`with(pems.object, expression)` evaluates the supplied expression using the elements of the supplied `pems.object`.

`subset(pems.object, expression)` behaves like `subset(data.frame, expression)`.

`print(pems.object)` provides a (to console) description of a pems object. This forshortens large datasets in a similar fashion to a tibble.

`plot(pems.object)` generates a standard R plot using selected data series in a pems object.

`names(pems.object)` returns a vector of the names of data series held in a pems object when used in the form `names(pems)` or resets names when used in the form `names(pems) <- new.names`.

`na.omit(pems.object)` returns the supplied pems object with all rows including NAs removed.

`summary(pems.object)` generates a summary report for data series held in a pems object.

`units(pems.object)` extracts the units from a supplied pems object when used in the form `units(pems)` or sets/resets units when used in the form `units(pems) <- new.units`.

Note

The pems object is intended to be a stricter version of a standard R `data.frame`. Unless the user specifically forces the operation, a `pems[]` or `pems[]<-` call is not allowed unless it fits exactly. So, for example by default the call `pems[,1]<-10` will not place 10 in every row of column one in the same fashion as `data.frame[,1]<-10`.

The logic behind this is that columns (elements) of pems objects are time-series. So, users would want to place these exactly and avoid any unintended wrapping. The `force` argument should be used in cases where data padding or wrapping operations are required.

`pems$name` and `pems$name<-` are not rigorously managed, so behave more like `data.frame$name` and `data.frame$name<-` calls, although even these do wrap by default.

`pems[[]]` provides access to structural components of the pems object, e.g. `pems[["data"]]` extracts the `data.frame` component of the pems object, `pems[["units"]]` extracts the units component, etc. See also [pems.structure](#).

Author(s)

Karl Ropkins

References

generics in general:

H. Wickham. Advanced R. CRC Press, 2014.

(Not yet fully implemented within this package.)

Examples

```
##example 1
##basics pems handling
```

```
#extract a subset pems object from pems.1
a <- pems.1[1:4, 1:5]
a

#indices work like data.frame
#a[x] and a[,x] recovers element/column number x
#a[x,] recovers row number x
#a["name"] and a[, "name"] recovers element/column named "name"
#a[4:5, "name"] recovers rows 4 to 5 of element/column named "name"
#a[x,y] <- z inserts z into a at row x, element y
#etc

#insert 10 in at element 3, row 2
a[2,3] <- 10
a

#replace element conc.co2 with conc.co
a["conc.co2"] <- a$conc.co
a

#Note: by default pems objects subsetting and inserting is
#more rigorous than data.frame subsetting/insertion
#for example, a[1:2, "conc.hc"] <- 8 would generate error
#because the target, a[1:2,], and insert, 8, dimensions do not
#match exactly: target 2 x 1; insert 1 x 1

#By default no wrapping is applied.

#the force argument allows the user to control how mismatching
#targets and insertions are handled

#na pad target for larger insert
a[1:2, "conc.hc", force="na.pad.target"] <- 1:5
a

#Note here when the target is padded existing enteries are NOT
#overwritten if they are not declared in a[, and the next
#previously unassigned cells are used for any extra cases in
#the insert.

#wrap insert to fill hole made by a[i,j]
a[1:2, "conc.hc", force="fill.insert"] <- 8
a

#pems$name <- value is equivalent to
#pems[name, force=c("na.pad.target", "na.pad.insert")]
a$new <- 1:4
a
```

2.2.2.generic.pems.element.handlers

Generic handling of pems.element objects

Description

pems elements objects can be manipulated using generic functions like print, plot and summary in a similar fashion to objects of other R classes.

Usage

```
## S3 method for class 'pems.element'
x[i, ..., force = TRUE, wrap = FALSE]

## S3 replacement method for class 'pems.element'
x[i, ..., force = TRUE, wrap = FALSE] <- value

## S3 method for class 'pems.element'
as.pems(x, ...)

## S3 method for class 'pems.element'
print(x, ..., n = NULL, rows = NULL, width = NULL)

## S3 method for class 'pems.element'
plot(x, y = NULL, xlab = NULL, ylab = NULL, ...)

## S3 method for class 'pems.element'
units(x)

## S3 replacement method for class 'pems.element'
units(x) <- value

## S3 method for class 'pems.element'
summary(object, ...)

## S3 method for class 'pems.element'
round(x, ...)
```

Arguments

x, object	(An Object of pems.element class). For direct use with print, plot, summary, etc. NOTE: Object naming (i.e., x or object) is determined in parent or base function in R, so naming can vary by method.
i	Element indices, which operate in a similar fashion to vector indices.

...	Addition options, typically passed to associated default method(s).
force, wrap	(Logicals) Data element handling options: force forces data to fit its destination; wrap expands data to fit its destination by wrapping the source pems.element.
value	(Vector) For calls in pems.element[1] <- value or units(pems.element) <- value, the value to be inserted.
n, rows, width	(Numerics) For print(pems), number of elements, rows or screen width to foreshorten print output to.
y, xlab, ylab	(other plot arguments). As with the default plot method, y is an optional second data vector, typically numeric, and xlab and ylab are labels to use on x and y axes.

Value

Generic functions provide appropriate (conventional) handling of objects of 'pems.elements' class:

print(pems.element) provides a (to console) description of the supplied pems.element object.

plot(pems.element) generates a standard R plot of the supplied pems.element.

units(pems.element) extracts the units from the supplied pems.element.

Note

Special round(pems.element) is required to as a wrapper to round.Date and round.POSIXt handling.

Author(s)

Karl Ropkins

Examples

```
#the velocity pems.element in pems.1
pems.1$velocity
```

2.2.pems.structure *'pems' object structure*

Description

This pages provides a brief outview description of the 'pems' object structure. It also lists some associated functions

Usage

```

getPEMSElement(x, pems = NULL, units = NULL, ...,
               fun.name="getPEMSElement", if.missing = "stop",
               .x = enquo(x))

getPEMSData(pems=NULL, ..., fun.name = "getPEMSData",
            if.missing = "stop", .pems = enquo(pems))

getPEMSConstants(pems=NULL, ..., fun.name = "getPEMSConstants",
                 if.missing = "stop", .pems = enquo(pems))

pemsData(pems=NULL, ...,
         fun.name = "pemsData", if.missing = "stop",
         pems.name = deparse(substitute(pems)))

pemsConstants(pems=NULL, ...,
              fun.name = "pemsConstants", if.missing = "stop",
              pems.name = deparse(substitute(pems)))

pemsHistory(pems=NULL, ...,
            fun.name = "pemsHistory", if.missing = "stop",
            pems.name = deparse(substitute(pems)))

```

Arguments

<code>x</code>	(Required vector, typically <code>pems.element</code>) For <code>getPEMSElement</code> , the required data element.
<code>pems</code>	(pems object) If supplied, the pems object to search for <code>x</code> before checking the parent environments and R workspace.
<code>units</code>	(Optional) The units that <code>x</code> should be supplied in (handled by convertUnits).
<code>...</code>	(Optional) Other Arguments, currently ignored.
<code>fun.name, if.missing, pems.name, .x, .pems</code>	(Various) Other options using for <code>pems.utils</code> house-keeping. See check... for definitions, although generally these can be ignored by users. See Note below.

Details

The `pems` object is a managed data.frame. It has five main components: `data`, `units`, `constants`, `history` and `tags`. `data` is the main data.frame. Each element (named data.frame column) is a data-series of the original PEMS data. `units` are the associated unit definitions. `constants` is a list of associated constants that are to be used with the `pems` object. (The preference order is arguments given in a call then constants declared in the `pems` object then constant defaults held by the `pems.utils` package.) `history` is a log of `pems` object modifications. `tags` are any other components that the user wishes to add to a `pems` object as identifiers.

`getPEMSElement` gets a requested `pems.element` from `pems` if supplied or locally.

`pemsData` and `getPEMSData` get the data component of a supplied `pems` object.

`pemsConstants` and `getPEMSConstants` get all constants locally defined for the supplied `pems` object.

`pemsHistory` gets the history of supplied `pems` object.

Value

`getPEMSElement` returns the requested element of a supplied `pems` object as a managed vector or `pems.element`, if available. If missing, error handling is by `checkIfMissing`. See [check...](#) for more details.)

`pemsData` returns the data component of a supplied `pems` object as a `data.frame`.

`getPEMSData` returns the data component of a supplied `pems` object as a `data.frame`.

`pemsConstants` returns the constants component of a supplied `pems` object as a `list`.

`getPEMSConstants` returns the constants component of a supplied `pems` object as a `list`.

`pemsHistory` returns the history component of a supplied `pems` object as a `list`.

Note

`pems...` functions are in development `pems` object handlers. They are intended for convenient 'front of house' use. As part of this role, their structure will evolve over time, so arguments and operations may change based on user feedback. Those wishing to develop future-proof third party functions should also consider `check...` functions when developing their code. See [common.calculations](#) for some Examples.

`getPEMS...` functions are a revision of earlier `pems...` `pems` object handlers. They are intended for convenient 'front of house' use.

`rlang` and `dplyr` functions now do all the heavy lifting for `getPEMSElement`.

Author(s)

Karl Ropkins

References

`rlang` and `dplyr` package functions now do all the heavy lifting for `getPEMSElement`.

Lionel Henry and Hadley Wickham (2018). `rlang`: Functions for Base Types and Core R and 'Tidyverse' Features. R package version 0.2.0. <https://CRAN.R-project.org/package=rlang>

Hadley Wickham, Romain Francois, Lionel Henry and Kirill Muller (2017). `dplyr`: A Grammar of Data Manipulation. R package version 0.7.4. <https://CRAN.R-project.org/package=dplyr>

See Also

See Also: [check...](#) for `check...` function equivalents; [pems.generics](#) for `pems` object class generic functions.

Examples

```
#####
##example 1
#####

#basic usage

#using example data pems.1
#(supplied as part of pems.utils package)

#pems structure
pems.1

# extracting the pems.1 element velocity
getPEMSElement(velocity, pems.1)

## Not run:
#generic (SE) equivalents
pems.1$velocity
pems.1["velocity"]

## End(Not run)
```

2.3.1.merge.data.pems *Merging data and pems objects*

Description

Various pems.utils functions to merge data of different types.

Usage

```
#basic alignment
align(data1, data2, n = 0, ...)

#alignment based on correlation
cAlign(form, data1 = NULL, data2 = NULL, ...)

#alignment based on time.stamp
tAlign(form, data1, data2 = NULL, order=TRUE, ...)

#basic stacking
stackPEMS(..., key=key, ordered=TRUE)

#historical
```

```
findLinearOffset(x = NULL, y = NULL, ...)

#c wrappers
C_ylagxCOR(x, y)
```

Arguments

data1, data2	(pems or data.frame; optional for cAlign, required for other alignment functions) pems objects or data.frames to be aligned.
n	(numeric; required) An offset to be applied to data2 when aligning data1 and data2. The default, n = 0, applies no offset and directly aligns the two supplied data sets, first row to first row.
...	(Any other arguments) For stackPEMS this is typically a series of pems objects to be stacked. For other functions, this may be passed on but are typically ignored. See Notes.
form	(formula; required) A formula identifying the elements in the supplied data sets to be used as references for the alignment. This typically takes the form, e.g. cAlign(x~y, d1, d2) where d1\$x and d2\$y are the data series to be used to correlation align the two data sets.
order	(logical; optional) If TRUE the function orders the data.
key	(character or NSE) For stackPEMS the name to key column that identifies the data sources of elements in a stack of pems objects.
ordered	(logical; default TRUE) For stackPEMS, when creating the source key should the order pems objects were supplied be retained.
x, y	(Required objects, various classes) For bindPEMS, two pems, data.frame, pems.elements or vectors to be bound together. For findLinearOffset, two pems.elements or vectors to be aligned.

Details

The align function accepts two pems objects, data.frame, etc, and returns a single dataset (as a pems object) of the aligned data. An extra argument, n, may be supplied to offset the starting row of the second data set relative to the first. It is intended to be used in the form:

```
aligned.data <- align(data1, data2) #aligned row 1-to-1
aligned.data <- align(data1, data2, 3) #row 3-to-1, etc
```

The cAlign function accepts a formula and up to two data sets and returns a single data set (as a pems object) of correlation aligned data. This uses the best fit linear offset correlation for the elements identified in the formula term.

It is intended to be used in the form:

```
aligned.data <- cAlign(name1~name2, data1, data2)
C_ylagxCOR is a wrapper for C++ code used by cAlign.
```

The tAlign function accepts a formula and two data sets and returns a single data set (as a pems object) of the time stamp aligned data. This is this done by matching entries in the elements identified in the formula term.

It is intended to be used in the form:

```
aligned.data <- tAlign(name1~name2, data1, data2)
```

The stackPEMS function stacks two or more pems objects and returns a single pems object. stackPEMS stacks using dplyr function bind_rows so handles pems with column names that do not completely intersect. However it also attempts to units match. It is intended to be used in the form:

```
stacked.data <- stackPEMS(data1, data2)
```

Historical functions:

findLinearOffset is historical code.

Value

align, cAlign, tAlign, etc all return a single object of pem class containing the aligned data from data1 and data2.

findLinearOffset returns the best fit offset for y relative to x.

Note

These functions are under revision and need to be handled with care.

cAlign: By default cAlign generates an alignment plot and returns a pems object of aligned data. But it also allows several hidden arguments to refine outputs, the logicals plot, offset and pems, which turn off/on plot, offset and pems reporting individually, and output = c("plot", "offset", "pems") or combinations thereof also provides a single argument alternative.

bindPEMS: The historical function bindPEMS has been superceded by align.

findLinearOffset: findLinearOffset is currently retained but will most likely be removed from future versions of pems.utils.

The call cAlign(x~y, output = "offset") is equivalent to findLinearOffset(x, y).

Author(s)

Karl Ropkins

References

align uses the dplyr function full_join.

cAlign function uses the stats function ccf.

tAlign uses the dplyr function full_join.

See Also

See also: [cbind](#) for standard column binding in R; [dplyr](#) for [full_join](#).

Examples

```
#####
##example 1
#####

##data vector alignment

#make two offset ranges
temp <- rnorm(500)
x <- temp[25:300]
y <- temp[10:200]

#plot pre-alignment data
plot(x, type="l"); lines(y, col="blue", lty=2)

#estimated offset
findLinearOffset(x,y)
#[1] -15

#applying linear offset
ans <- align(x, y, findLinearOffset(x,y))
names(ans) <- c("x", "y")

#plot post-alignment data
plot(ans$x, type="l"); lines(ans$y, col="blue", lty=2)

#shortcut using cAlign
## Not run:
plot(x, type="l"); lines(y, col="blue", lty=2)
ans <- cAlign(x~y)
plot(ans$x, type="l"); lines(ans$y, col="blue", lty=2)

## End(Not run)

#####
##example 2
#####

##aligning data sets
##(pems object example)

#make some offset data
p1 <- pems.1[101:200, 1:5]
p2 <- pems.1[103:350, 1:3]

#correlation alignment using ccf
ans <- cAlign(~conc.co, p1, p2)

#this aligns by comparing p1$conc.co and p2$conc.co
#and aligning at point of best linear regression fit
```

```

## Not run:

#compare:

cAlign(~conc.co, p2, p1)
cAlign(conc.co2~conc.co, p1, p2)
#(aligns using p1$conc.co2 and p2$conc.co)
cAlign(conc.co2~conc.co, p1)
#(realigns just conc.co within p1 based on best fit
# with conc.co2 and returns as output ans)

#time stamp alignment
tAlign(~time.stamp, p1, p2)

#this aligns by pairing elements in p1$time.stamp
#and p2$time.stamp
#(if time stamps have different names
# tAlign(time1~time2, p1, p2), the time stamp name
# from p1 would be retained when merging p1$time1
# and p2$time2, generating [output]$time1)

## End(Not run)

#####
##example 3
#####

##stacking pems

#make some offset data
p1 <- pems.1[1:2, 1:4]
p2 <- pems.1[3, 2:4]
p3 <- pems.1[4:6, 1:3]

#stack
stackPEMS(p1, p2, p3, key=source)

```

2.3.2.conditioning.pems.data

Data conditioning for pems data

Description

Various functions for the conditioning of pems objects.

Usage

```
cutBy(ref = NULL, ..., data = NULL, cut.method = NULL,
      labels = NULL, fun.name = "cutBy")
```

```
cutByRow(ref = NULL, n = 4, rows = NULL, ..., data = NULL,
         fun.name = "cutByRow")
```

Arguments

<code>ref</code>	(Data series typically vector) The reference data series to consider when making a vector of subset markers/indices. See Details.
<code>...</code>	(Optional) Other arguments, currently passed on to <code>pems.utils</code> management functions.
<code>data</code>	(Optional <code>data.frame</code> or <code>pems</code> object) The data source if <code>ref</code> is supplied in either a <code>data.frame</code> or <code>pems</code> object.
<code>cut.method</code>	(Optional function) For <code>cutBy</code> only, the method to use when cutting <code>ref</code> . If not supplied, <code>cutByRow</code> used by default.
<code>labels</code>	(Character vector) For <code>cutBy</code> only, a vector of names to be assigned to the cut regions.
<code>fun.name</code>	(function management argument) <code>fun.name</code> is the name of the parent function, to be used in error messaging.
<code>n, rows</code>	(numerics) <code>n</code> sets the number of equal intervals to attempt to cut the data into. <code>rows</code> sets the exact rows at which to cut the data at. If <code>n</code> is applied and the length of <code>ref</code> is not exactly divisible by <code>n</code> a best attempt is made. If both <code>n</code> and <code>rows</code> are set, <code>rows</code> is applied.

Details

`cutBy` and `cutBy...` functions generate a vector of subset markers or indices based of the type of cut applied and the range/size of the reference, `ref`. See Value regarding outputs.

`cutBy` is a wrapper for other `cutBy...` functions. It provides additional options for `cut.marker` naming.

`cutByRow` assigns cut regions based in row number.

Value

By default results are returned as `pems.elements`.

The `cut.marker` vector generated by `cutBY` and `cutBy...` functions can then be used to condition and subsample data in `pems` objects.

Warning

Currently, no warnings.

Note

Various other `cutBy...` options can be very simply encoded.

Author(s)

Karl Ropkins

References

References in preparation.

See Also

[cut](#), etc. in the main R package.

Examples

```
#####  
##example 1  
#####  
  
#basic usage  
  
#working with a temporary pems  
  
temp <- pems.1  
  
#cut into equal subsets  
  
temp$ref <- cutBy(velocity, n= 5, data=temp)  
  
pemsPlot(local.time, velocity, cond=ref, data=temp,  
          type="l", layout=c(1,5))  
  
#cut at three points  
  
temp <- pems.1  
temp$ref <- cutBy(velocity, rows=c(180,410,700), data=temp)  
  
pemsPlot(local.time, velocity, cond=ref, data=temp,  
          type="l", layout=c(1,5))
```

 2.3.3.time.handlers *pems Data Time Handlers*

Description

Time handlers are subset of `pems.utils` functions that work on or with time records (`time.stamp` and `local.time`).

Usage

```
regularize(data, Hz=1, ...)
```

```
repairLocalTime(data, local.time, ref, ..., reset.count = TRUE,  
                fun.name = "repairLocalTime")
```

Arguments

<code>data</code>	(Required, typically <code>pems</code>) The dataset to be worked with. For <code>regularize</code> , the dataset to regularize (see below).
<code>Hz</code>	(For <code>regularize</code>) (Required numeric) The time resolution to regularize the data to in Hertz. So, the default, <code>Hz=1</code> is one measurement (or row of data) per second.
<code>...</code>	(Optional) Other arguments, typically passed on.
<code>local.time</code>	(For <code>repairLocalTime</code>) (Required <code>pems.element</code>) The <code>local.time</code> <code>pems.element</code> to work been repaired.
<code>ref, reset.count</code>	(For <code>repairLocalTime</code>) (Other arguments) <code>ref</code> is a second source that <code>local.time</code> can be inferred from in cases where <code>local.time</code> records are missing. If <code>TRUE</code> , <code>reset.count</code> resets <code>local.time</code> so it starts at 0.
<code>fun.name</code>	(character) (<code>pems handler</code>) argument used by <code>pems.utils</code> . These can typically be ignored.

Details

`regularize` attempts to extrapolate a regular series, generated at the time resolution requested, from the supplied data. It can be useful for the regularization of irregularly time-logged data and for hole-filling missing records but should not be used aggressively, to convert 1Hz to 10Hz data.

`repairLocalTime` attempts to repair an incomplete `local.time` record. For example, if you merge two datasets with overlapping but different time ranges, one may not track the time range of the other and this can generate incomplete time records. This function attempts to hole-fill such cases.

Value

`regularize` returns the supplied dataset (`data`) with time-series (`time.stamp` and `local.time`) are regularized at the requestion time resolution, based on `Hz` value. It uses `approx` the estimate associated changes for other data-series.

`repairLocalTime` returns a repaired `local.time` pem.element, typically the supplied `local.time` with any holes (NAs) it can fill filled.

Note

All time handlers should be used with care.

Author(s)

Karl Ropkins

References

`regularize` uses `approx`:

Base R Stats package function based on Becker, R. A., Chambers, J. M. and Wilks, A. R. (1988) *The New S Language*. Wadsworth & Brooks/Cole.

A lot of leg-work testing `regularize` was done by then Leeds MSc Student Adrian Felipe Ortega Calle.

See Also

[approx](#) regarding data regularization methods.

2.3.4.unit.handlers *data unit handlers*

Description

Various `pems.utils` functions for the management of data units.

Usage

```
getUnits(input = NULL, data = NULL, ...,
         if.missing = c("stop", "warning", "return"))
```

```
setUnits(input = NULL, units = NULL, data = NULL, ...,
         if.missing = c("stop", "warning", "return"),
         output = c("input", "data.frame", "pems", "special"),
         force = FALSE, overwrite = FALSE)
```

```
convertUnits(input = NULL, to = NULL, from = NULL, data = NULL, ...,
```

```

    if.missing = c("stop", "warning", "return"),
    output = c("input", "data.frame", "pems", "special"),
    unit.conversions = NULL, force = FALSE, overwrite = FALSE)

#local unit.conversion method handling

addUnitConversion(to = NULL, from = NULL, conversion = NULL,
  tag = "undocumented",
  unit.conversions = ref.unit.conversions, ...,
  overwrite = FALSE)

addUnitAlias(ref = NULL, alias = NULL,
  unit.conversions = ref.unit.conversions, ...)

listUnitConversions(unit.conversions = ref.unit.conversions, ...,
  verbose = FALSE, to = NULL, from = NULL)

```

Arguments

input	(vector, object or object element) An input, e.g. a vector of speed measurements.
data	(data.frame, pems object) If supplied, the assumed source for an input. This can currently be a standard data.frame or a 'pems' object. Note: if an input is not found in data, the parent environment is then also checked before returning an error message.
units, to, from, ref, alias, tag	(Character vectors). Unit ids. units sets the units of input in setUnits. to sets the units to convert input to when using convertUnits. The additional arguments from can be used to apply unit conversions to inputs with un-defined or mismatched units, but requires the extra argument force = TRUE to confirm action. When working with local unit conversions to and from should be used to identify specific conversions, e.g. when using addUnitConversion to add a new unit conversion method, and ref and alias should be used to identify a current unit id and new alias, respectively, when using addUnitAlias. tag is an optional more detailed conversion description, intended for use in method documentation. (See Below for further details.)
...	(Optional) Other arguments, currently ignored.
if.missing	(Optional character vector) What the function should do if things do not go as expected. Current options include: "stop" to stop the function with an error message; "warning" to warn users that expected information was missing but to continue running the parent code; or "return" to continue running the parent code without any warnings.
output	(Character vector) Output mode for function results. Options currently include: special, input, data.frame, and pems. See force, overwrite and Values below for further details.
force	(Logical) Should a unit change to attempted even if checking indicates a mismatch, e.g. an attempt to set the units of an input that already has units assigned.

<code>overwrite</code>	(Logical) If 'same name' cases are encountered when packing/repacking an output into a <code>data.frame</code> or <code>pems</code> object, should the function overwrite the case in the target <code>data.frame</code> or <code>pems</code> object with the modified input? (If <code>FALSE</code> , a new element is generated with a unique name in the form <code>[input.name].number</code> .)
<code>unit.conversions</code>	(Optional list) If supplied, <code>unit.conversions</code> is a 'look up' table for unit conversion methods. By default, functions in <code>pems.utils</code> use the reference ref.unit.conversions , but this can be copied to the workspace and updated to provide the user with a means of updating and expanding the method set.
<code>conversion</code>	(Numeric or function) When adding or updating a conversion method using <code>addUnitConversion</code> , the conversion method. This can be a numeric, in which case it is assumed to be a multiplication factor (and converted to a function in the form <code>function(x) x * conversion</code>) or a function to be applied directly to an input.
<code>verbose</code>	(Logical) For <code>listUnitConversions</code> . Should <code>unit.conversions</code> be reported in detail? By default (<code>verbose = FALSE</code>) only unit conversion tags are reported.

Details

`getUnits` returns the units of an input.

`setUnits` sets/resets the units of an input.

`convertUnits` converts the units of an input.

`addUnitConversion` adds a conversion method to a local version of the unit conversion look-up table. Methods should be supplied as `to` and `from` unit ids and an associated `conversion`. A `tag` can also be supplied to provide a more detailed description of the conversion for use in documentation.

`addUnitAlias` adds an alias for an existing unit id in a local version of the unit conversion look-up table. The existing unit id should be identified using `ref` and the new alias should be assigned using `alias`. The `alias` is added to all `to` and `from` elements containing `ref` to allow users to work with alternative unit abbreviations.

`listUnitConversions` lists the methods a supplied unit conversion look-up table. If `to` and/or `from` arguments are also supplied, these are used to subsample relevant methods.

Value

`getUnits` returns the units of an input as a character vector if available, else it returns `NULL`.

`setUnits` sets the units of an input to a supplied value, `units`, if they have not already be set or if `force = TRUE`. The result is returned as the modified input alone, the modified input as an element in a `data.frame`, or the modified input as an element in a `pems` object (depending on output setting). If either a `data.frame` or `pems` object is supplied as `data`, this is used as the target when repacking the output. (Note: `output = "special"` is a special case which allows the function to select the output mode based on the type of data supplied.

`convertUnits` converts the units of an input. Typically, this is done by setting the required new units, using `to`, and letting the function select a suitable conversion method. However, conversions can be forced by setting `from` and `force = TRUE` to apply a specific `to/from` method to an input

regardless of the actual units of input. As with `setUnits`, results can be output as `input`, `data.frame` or `pems` objects.

`addUnitConversion` returns a supplied unit conversion look-up table (or in its absence the reference `ref.unit.conversions`) subject to the requested addition or update. Note: modifications that change exist information require the extra argument `overwrite = TRUE` as confirmation.

`addUnitAlias` returns a supplied unit conversion look-up table (or in its absence the reference `ref.unit.conversions`) subject to the requested alias addition.

`listUnitConversions` returns summary descriptions of methods in the supplied unit conversion look-up table (or in its absence the reference `ref.unit.conversions`). Additional arguments, `to` and `from`, can be used to select unit conversions of particular relevance.

Note

This set of functions is intended to provide a flexible framework for the routine handling of data units.

Author(s)

Karl Ropkins

References

References in preparation

See Also

[pems.element](#)

Examples

```
#####
##example 1
#####

#work with data units

#getting units (where assigned)
getUnits(velocity, pems.1) #km/h

#setting units
a <- 1:10
a <- setUnits(a, "km/h") #add unit

#alternative
#using pems.element
#a <- pems.element(a, units="km/h", name = "a")

#changing units
convertUnits(a, "mi/h")
```

```

# [1] 0.6213712 1.2427424 1.8641136 2.4854848 3.1068560 3.7282272 4.3495983
# [8] 4.9709695 5.5923407 6.2137119
# pems.element; [unnamed] [mi/h] [n = 10]

#####
##example 2
#####

#working with local unit conversions
#adding/updating unit conversion methods

#make a local reference
ref.list <- ref.unit.conversions

#add a miles/hour alias to mi/h
ref.list <- addUnitAlias("mi/h", "miles/hour", ref.list)

#add a new conversion
ref.list <- addUnitConversion(to = "silly", from = "km/h",
                             conversion = function(x) 12 + (21 * x),
                             tag = "kilometers/hour to some silly scale",
                             unit.conversions = ref.list)

#use these
convertUnits(a, "miles/hour", unit.conversions = ref.list)

# [1] 0.6213712 1.2427424 1.8641136 2.4854848 3.1068560 3.7282272 4.3495983
# [8] 4.9709695 5.5923407 6.2137119
# units: "miles/hour" (as above but using your unit abbreviations)

convertUnits(a, "silly", unit.conversions = ref.list)

# [1] 33 54 75 96 117 138 159 180 201 222
# units: "silly" (well, you get what you ask for)

```

3.1.1.common.calculations

Common calculations

Description

Various common calculations associated with PEMS data.

Usage

```

calcDistance(speed = NULL, time = NULL, data = NULL,
             ..., fun.name = "calcDistance")

```

```

calcSpeed(distance = NULL, time = NULL, data = NULL,
           ..., fun.name = "calcSpeed")

calcAccel(speed = NULL, time = NULL, data = NULL,
           ..., method = 2, fun.name = "calcAccel")

calcAcceleration(speed = NULL, time = NULL, data = NULL,
                 ..., method = 2, fun.name = "calcAccel")

calcJerk(accel = NULL, time = NULL, data = NULL,
         ..., fun.name = "calcJerk")

#associated

calcChecks(fun.name = "calcChecks", ..., data = NULL,
           if.missing = c("stop", "warning", "return"),
           output = c("input", "data.frame", "pems", "special"),
           unit.conversions = NULL, overwrite = FALSE)

calcPack(output = NULL, data = NULL, settings = NULL,
         fun.name = "calcPack", this.call = NULL)

```

Arguments

speed, time, distance, accel	(Required data series typically vectors) The inputs to use when doing a calculation. These can typically be vectors or elements in either a <code>data.frame</code> or <code>pems</code> object.
data	(Optional <code>data.frame</code> or <code>pems</code> object) The data source if either a <code>data.frame</code> or <code>pems</code> object is being used.
...	(Optional) Other arguments, currently passed on to <code>calcChecks</code> .
fun.name	(Optional character) The name of the parent function, to be used in error messaging.
if.missing, output, unit.conversions, overwrite, settings, this.call	(Various) Along with <code>data</code> and <code>fun.name</code> , arguments used by <code>calcCheck</code> and <code>calcPack</code> to manage error and unit handling and workhorse <code>calc...</code> operations. These are typically passed to the appropriate <code>check...</code> or <code>...Units</code> function for evaluation. See <code>Details</code> , <code>Note</code> and <code>Examples</code> below.
method	(Character) Currently for <code>calcAccel</code> only. The method to use if options exist.

Details

With the exception of `calcChecks` and `calcPack`, `calc...` functions are common calculations.

`calcDistance` calculates distance (in m) using speed and time.

`calcSpeed` calculates speed (in m/s) using distance and time.

`calcAccel` calculates acceleration (in m/s/s) using speed and time.

`calcJerk` calculates jerk (rate of change of acceleration in m/s/s/s) using acceleration and time.

By default results are returned as `pems.elements`. Other options include returning as the supplied data plus the results as either a `data.frame` or a `pems` object. See Note below.

Unit management is by `convertUnits`. See Note below.

The extra functions `calcChecks` and `calcPack` are add-ins that anyone can use to develop other similar functions. They are added at the start and end of standard `calc...` functions to provide an option to use with third-party code. See Note.

Value

With the exception of `calcChecks` and `calcPack`, all `calc...` functions return either a `pems.element` vector, `data.frame` or `pems` object, depending on output setting and data supplied.

Note

Unit handling in `pems.utils` is via `checkUnits`, `getUnits`, `setUnits` and `convertUnits`. Allowed unit conversion methods have to be defined in `ref.unit.conversions` or a locally defined alternative supplied by the user. See `convertUnits` for an example of how to locally work with unit conversions.

`calc.dist` and `calc.accel` are alternatives to `calcDistance` and `calcAccel`.

The functions `calcChecks` and `calcPack` are currently under revision and likely to be replaced in future versions of `pems.utils`.

Author(s)

Karl Ropkins

References

References in preparation.

See Also

`calcVSP` for VSP calculations. `calcEm` for emissions calculations.

Examples

```
#####
##example 1
#####

#basic usage

#calculated accel as pems.element

calcAccel(velocity, local.time, pems.1)
```

```

#answer returned as supplied pems + calculated accel

calcAccel(velocity, local.time, pems.1, output = "pems")

#or, if you would rather...
## Not run:
pems.1$accel <- calcAccel(velocity, local.time, pems.1)

## End(Not run)

#####
#example 2
#####

#making wrappers for routine data processing

my.pems <- list(pems.1, pems.1)

sapply(my.pems, function(x)
      calcAccel(velocity, local.time, data=x))

#ans = accel data series for each pems in my.pems list

#           [,1]      [,2]
# [1,]      NA       NA
# [2,] 0.00000000 0.00000000
# [3,] 0.05555556 0.05555556
# [4,] 0.00000000 0.00000000
# [5,] -0.02777778 -0.02777778
# [6,] 0.05555556 0.05555556
#      ....

#note:
#sapply if you can/want to simplify outputs
#lapply if you want to keep output as a list of answers

```

3.1.2.vsp.calculations

Vehicle Specific Power (VSP) calculations

Description

Functions associated with VSP calculations.

Usage

```

calcVSP(speed = NULL, accel = NULL, slope = NULL,
        time = NULL, distance = NULL, data = NULL,

```

```

    calc.method = calcVSP_JimenezPalacios,
    ..., fun.name = "calcVSP", this.call = NULL)

calcVSP_JimenezPalacios(speed = NULL, accel = NULL,
    slope = NULL, vehicle.weight = NULL, vsp.a = NULL,
    vsp.b = NULL, vsp.c = NULL, vsp.g = NULL, ..., data = NULL,
    fun.name = "calcVSP_JimenezPalacios",
    this.call = NULL)

binVSP(..., bin.method="ncsu.14")

#associated methods
binVSP_NCSU.14(vsp = NULL, data = NULL,
    ..., fun.name="binVSP_NCSU.14")
binVSP_MOVES.23(vsp = NULL, speed = NULL, data = NULL,
    ..., fun.name="binVSP_MOVES.23")

```

Arguments

speed, accel, slope, time, distance, vsp
 (Typically pems.element vectors) speed, accel, slope, time and distance are possible inputs for VSP calculation. vsp and speed are possible inputs for VSP binning methods. (See Notes about inputs and methods.)

data
 (Optional, typically pems) The data source for inputs.

calc.method, bin.method
 (Required functions) calc.method is the function used to calculate VSP (default calcVSP_JimenezPalaciosCMEM). bin.method is the methods used when binning VSP measurements. (See Notes.)

...
 (Optional) Other arguments, currently passed on as supplied to e.g. calc.method (default calcVSP_JimenezPalaciosCMEM) and pems.utils functions as appropriate.

fun.name
 (Optional character) The name of the parent function, to be used in error messaging.

this.call
 (Optional) Initial call, should generally be ignored. See [codecommon.calculations](#) for further details.

vehicle.weight, vsp.a, vsp.b, vsp.c, vsp.g
 (Numerics) VSP constants. If not supplied, defaults are applied. See Below.

Details

calcVSP... functions calculate VSP:

calcVSP is a wrapper function which allows users to supply different combinations of inputs. VSP calculations typically require speed, acceleration and slope inputs. This wrapper allows different input combinations, e.g.:

time and distance (time and distance -> speed, time and speed -> accel)

time and speed (time and speed -> accel)

speed and accel

This then passes on speed, accel and (if supplied) slope to the method defined by `calc.method`. (This means other VSP functions run via `calcVSP(..., calc.method = function)` share this option without needed dedicated code.)

`calcVSP_JimenezPalacios` calculates VSP according to Jimenez Palacios methods. See References and Note below.

`binVSP` generates VSP Mode bins depending on method applied.

`binVSP_NCSU`. 14 bins supplied vsp using the 14 bin method described in Frey et al 2002.

`binVSP_MOVES`. 23 bins supplied vsp using that and speed and the 23 bin MOVES method (See Note).

Value

`calcVSP_JimenezPalacios` and `calcVSP` by default use Jimenez Palacios method to calculate VSP in kW/metric ton.

`binVSP` generates a `pems.element` factor vector of VSP Mode Bin assignments.

Note

`calcVSP...` constants can be set/modified in the calculation call, e.g. `calcVSP(..., vsp.a = [new.value])`. If not supplied, defaults are used (see References).

`binVSP_MOVES`. 23 is in-development. Do not use without independent confirmation of values.

Unit handling in `pems.utils` is via [checkUnits](#), [getUnits](#), [setUnits](#) and [convertUnits](#). See [common.calculations](#) for details.

Author(s)

Karl Ropkins

References

`calcVSP_JimenezPalacios` uses methods described in:

Jimenez-Palacios, J.L. (1999) Understanding and Quantifying Motor Vehicle Emissions with Vehicle Specific Power and TILDAS Remote Sensing. PhD Thesis, Massachusetts Institute of Technology, Cambridge, MA.

`vehicle.weight` is the vehicle mass (in metric tons), and `vsp.a`, `vsp.b`, `vsp.c` and `vsp.g` are the calculations constants for:

$$vsp = speed * (a * accel + (g * slope) + b) + (c * speed^3)$$

By default: $a = 1.1$, $b = 0.132$, $c = 0.000302$ and $g = 0.132$ (as of Jimenez-Palacios, 1999).

Method ONLY INTENDED FOR vehicles < 3.855 metric tons.

`binVSP_NCSU`. 14 VSP binning as described in:

Frey, H.C., Unal, A., Chen, J., Li, S. and Xuan, C., 2002. Methodology for developing modal emission rates for EPA's multi-scale motor vehicle & equipment emission system. Ann Arbor, Michigan: US Environmental Protection Agency. (EPA420-R-02-027)

See Also

See [common.calculations](#) (and [checkUnits](#) and [convertUnits](#)) for details of data management.

Examples

```
#####
##example 1
#####

#basic usage

vsp <- calcVSP(velocity, time = local.time, data = pems.1)
#where the returned object, vsp, is vsp values as pems.element

ncsu.14 <- binVSP(vsp)
#where the returned object, ncsu.14, is the associated modal bin
# assignments based on the Frey et al (2002) 14 bin method.
```

3.1.3.emissions.calculations

Emission calculations

Description

Functions associated with emissions calculations.

Usage

```
calcEm(conc = NULL, calc.method = calcEm_HoribaPitot,
        analyte = NULL, ..., data = NULL, fun.name = "calcEm",
        force = FALSE, this.call = NULL)

calcEm_HoribaPitot(conc = NULL, time = local.time, exflow = exh.flow.rate,
                    extemp = exh.temp, express = exh.press, analyte = NULL,
                    delay = NULL, mm = NULL, ..., force = force, data = NULL,
                    fun.name = "calcEm_HoribaPitot", this.call = NULL)
```

Arguments

conc	(Data series, typically pems.element vector) Analyte/species concentrations, the main input for calculating emissions. If conc is a concentration data series from a standard pems source it should be named conc.[analyte] and pems.utils will manage it accordingly. See below for further details.
------	---

time, exflow, extemp, express	(Data series, typically pems.element vectors) Other inputs used when calculating emissions. The combination depending on the calculation method used (and set by calc.method).
calc.method	(Required function) The function to use to calculate emissions. (Default calcEm_HoribaPitot). See below for further details.
analyte	(Optional character vector) The analyte emissions are to be calculated for. If supplied, this is used as a reference when assigning molecule weight and other analyte properties if these are not provided as part of calculate call. If not supplied, pems.utils attempts to recover these from available sources, e.g. data if supplied as part of the calculation call or package references such as ref.chem .
...	(Optional) Other arguments, currently passed on to function provided as calc.method (default calcEm_HoribaPitot) and appropriate pems.utils functions.
data	(Optional pems object) The data source for inputs.
fun.name, this.call, force	(Various pems management functions) fun.name (character vector) the name of the parent function, to be used in error messaging. this.call the initial call (can generally be ignored). force (Logical) Should calcEm and calc.method ignore any error checking, e.g. units assignments, and do calculations anyway?
delay, mm	(Optional numerics) Emissions calculation constants. delay is the time delay between conc measurements and other timeseries. mm is the molecular mass of the analyte. If supplied, these in-call values supercede any preset in e.g. package look-up.tables.

Details

calcEm... functions calculate emissions.

calcEm is a wrapper function which is intended to provide a convenient front for emissions calculation methods. It accepts an input codeconc which it checks and passes on to calc.method, along with other supplied arguments.

calcEm_HoribaPitot calculates emissions using methods described in the Horiba OBS Operators Manual. In addition to conc, the function requires the time, and exhaust flow data series (measured by the OBS Pitot flow meter). By default, the function assumes that these are default names that are generated for these when standard OBS files are imported into R using the pems.utils import function [importOBS2PEMS](#). See References and Note below.

Value

calcEm_HoribaPitot (and calcEm by default) use Horiba Manual methods to calculate emissions (in g/s).

Note

calcEm... constants can be set/modified in the calculation call, e.g. calcEm(..., delay = [new.value]). If not supplied, these are first checked for in the associated pems object (if supplied), or set to default values. See References. If analyte-related constants are to be added to a pems object, these should

be named in the format '[type].[analyte]', e.g. delay.co for the delay constant to be used for the analyte CO.

Unit handling in pems.utils is via [checkUnits](#), [getUnits](#), [setUnits](#) and [convertUnits](#). See [common.calculations](#) for details.

Author(s)

Karl Ropkins

References

calcEm_HoribaPitot uses methods described in:

The Horiba Operators Manual.

See Also

See [common.calculations](#).

Examples

```
#####  
##example 1  
#####  
  
#basic usage  
  
em.co <- calcEm(conc.co, data = pems.1)  
  
#where the returned object, em.co, is a pems.element
```

3.2.analysis.summary.reports

Generating summary reports

Description

Various functions for generating summary reports for pems objects.

Usage

```
summaryReport(speed = NULL, time = NULL, accel = NULL,  
              distance = NULL, data = NULL, ...,  
              lod.speed = 0.1, lod.accel = 0.1,  
              fun.name = "summaryReport")
```

Arguments

speed, accel, time, distance	(Data series typically vectors) The inputs to use when doing a calculation. These can typically be vectors or elements in either a <code>data.frame</code> or <code>pems</code> object if supplied as data. See Details below regarding requirements.
data	(Optional <code>data.frame</code> or <code>pems</code> object) The data source if either a <code>data.frame</code> or <code>pems</code> object is being used.
...	(Optional) Other arguments, currently passed on to <code>calcChecks</code> which in turn provides access to <code>pems.utils</code> management arguments such as <code>if.missing</code> and unit handlers such as <code>unit.conversions</code> .
lod.speed, lod.accel	(numerics) The limits of detection for speed and accel measurements, respectively. [Note: if only one value is given for accel, the accel limits are assumed to be $c(-\text{lod.accel}, +\text{lod.accel})$].
fun.name	(Optional character) The name of the parent function, to be used in error messaging.

Details

`summaryReport` does not strictly require all the arguments `speed`, `accel`, `time` and `distance` as inputs. It calculates as many of the missing cases as it can using the `common.calculations` before halting an analysis or warning the user of any problems.

Unit management is by `convertUnits`. See Note below.

Value

`summaryReport` returns a one-row `data.frame` with twelve elements:

`distance.travelled.km` this total distance travelled (in km)

`time.total.s` the total time taken (in s)

`avg.speed.km.h` the mean speed as averaged across the total journey/dataset (in km/h)

`avg.running.speed.km.h` the mean speed while the vehicle was in motion (in km/h), assuming a 0.01 km/h accuracy for speed measurements.

`time.idle.s` and `time.idle.pc`, the time the vehicle was idling (in s and as a percentage, respectively), also assuming a 0.01 km/h cutoff for speed measurements.

`avg.accel.m.s.s` the mean (positive component of) acceleration (in m/s/s), assuming a 0.1 m/s/s cutoff for accel measurements.

`time.accel.s` and `time.accel.pc`, the time the vehicle was accelerating (in s and as a percentage, respectively), also assuming a 0.1 m/s/s cutoff for accel measurements.

`avg.decel.m.s.s` the mean deceleration (negative component of acceleration in m/s/s), assuming a -0.1 m/s/s cutoff for accel measurements.

`time.decel.s` and `time.decel.pc`, the time the vehicle was decelerating (in s and as a percentage, respectively), also assuming a -0.1 m/s/s cutoff for accel measurements.

Warning

Currently, `summaryReport` outputs have units incorporated into their names because the outputs themselves are unitless `data.frames`.

Note

Unit handling in `pems.utils` is via `checkUnits`, `getUnits`, `setUnits` and `convertUnits`. Allowed unit conversion methods have to be defined in `ref.unit.conversions` or a locally defined alternative supplied by the user. See `convertUnits` for an example of how to locally work with unit conversions.

Author(s)

Karl Ropkins

References

References in preparation.

See Also

`checkUnits` and `convertUnits` for data management.

Examples

```
#####
##example 1
#####

#basic usage

summaryReport(velocity, local.time, data=pems.1)

# distance.travelled.km time.total.s avg.speed.km.h avg.running.speed.km.h
# 1          6.186056          1000          22.2698          28.78538
# time.idle.s time.idle.pc avg.accel.m.s.s time.accel.s time.accel.pc
# 1           40           4          0.7921279          271          27.1
# avg.decel.m.s.s time.decel.s time.decel.pc
# 1          -0.9039449          238          23.8

#apply to multiple cases

my.pems <- list(pems.1, pems.1)

sapply(my.pems, function(x)
      summaryReport(velocity, local.time, data = x))

#           [,1]      [,2]
# distance.travelled.km 6.186056 6.186056
```

```

# time.total.s          1000      1000
# avg.speed.km.h        22.2698   22.2698
# avg.running.speed.km.h 28.78538 28.78538
# time.idle.s           40        40
# time.idle.pc          4         4
# avg.accel.m.s.s       0.7921279 0.7921279
# time.accel.s          271       271
# time.accel.pc         27.1      27.1
# avg.decel.m.s.s       -0.9039449 -0.9039449
# time.decel.s          238       238
# time.decel.pc         23.8     23.8

```

3.3.pems.plots

Various plots for pems.utils

Description

Various plot functions and visualization tools for pems objects.

Usage

```
#new plots
```

```
#pemsPlot
```

```
pemsPlot(x, y = NULL, z = NULL, ..., data = NULL, cond = NULL,
          units = TRUE, fun.name="pemsPlot", panel = panel.pemsPlot,
          scheme = pems.scheme)
```

```
#pemsPlot elements
```

```
pemsXYZCondUnitsHandler(x, y = NULL, z = NULL, cond = NULL,
                        data = NULL, units = TRUE, ..., fun.name = "pemsXYZCondHandler")
```

```
preprocess.pemsPlot(lattice.like = lattice.like, units = units, ...)
```

```
panel.pemsPlot(..., loa.settings = FALSE)
```

```
#WatsonPlot
```

```
WatsonPlot(speed, accel = NULL, z = NULL, ..., data = NULL,
            cond = NULL, units = TRUE, plot.type = 2, fun.name="WatsonPlot",
            scheme = pems.scheme)
```

```

#WatsonPlot elements

preprocess.WatsonPlot(lattice.like = lattice.like, ...)

panel.WatsonBinPlot(..., ref.line = TRUE, process.panel = panel.binPlot,
  plot.panel = panel.binPlot, omit.stopped = FALSE, process = TRUE,
  plot = TRUE, loa.settings = FALSE)

panel.WatsonContourPlot(..., plot.panel=panel.kernelDensity, process = TRUE,
  plot = TRUE, loa.settings = FALSE)

panel.WatsonSmoothContourPlot(..., plot.panel=panel.surfaceSmooth,
  process = TRUE, plot = TRUE, loa.settings = FALSE)

#ggplot2 (tidyverse)

## S3 method for class 'pems'
fortify(model, data, ...)

#old plots

latticePlot(x = NULL, data = NULL, plot = xyplot, panel = NULL,
  ..., greyscale = FALSE, fun.name = "latticePlot")

panel.PEMSXYPlot(..., grid=NULL)

XYZPlot(x = NULL, ..., data = NULL, statistic = NULL,
  x.res = 10, y.res = 20, plot = levelplot,
  fun.name = "XYZPlot")

```

Arguments

`x`, `y`, `z`, `cond` (Various) The main plot elements. `x` and `y` are typically plot coordinates. `z` is any additional information that could be used, e.g. to modify points plotted at (x, y) coordinates or generate a third axis for a surface plot. `cond` is a conditioning terms that can be used to subset the supplied data and generate multiple plot panels. See Note Below.

For new plots, these should be supplied individually, e.g. for `pemsPlot`:

```
pemsPlot(x, y, z, cond)
```

For old plots, these must be formulae.

For `latticePlot` the basic formula structure is $y \sim x \mid \text{cond}$.

For `XYZPlot` the basic formula structure is $z \sim y * x \mid \text{cond}$. `z` is optional, but when it is not supplied `z` it is treated as the bin count.

	See Notes and Examples.
<code>data</code>	(Optional <code>data.frame</code> or <code>pems</code> object) For most plots, the data source for plot elements, e.g <code>x</code> , <code>y</code> , <code>z</code> , etc, if not the current environment or a parent.
<code>units</code>	(Optional logical or list) for <code>pemsPlot</code> only Unit handling information. By default, <code>pems.utils</code> adds any known units to plot labels and allows in-plot unit management. Unit management is handled by <code>convertUnits</code> , and requested conversions need to assigned to an axis. So, for example, the call <code>pemsPlot(..., x.to="m/s")</code> would generate a plot with the x-axis in units of m/s (assuming <code>pems.utils</code> knows the unit conversion). <code>units.add.to.labels = FALSE</code> removes label unit suffixes but retains unit management. <code>units = FALSE</code> disables all unit-related plot handling.
<code>...</code>	(Optional) Other arguments, typically passed on.
<code>fun.name</code>	(Function management argument) <code>pems.utils</code> management settings, can typically be ignored by most users.
<code>panel</code> , <code>plot.panel</code> , <code>process.panel</code>	(Functions) These functions are used to generate the content of individual plot panels. Typically, all in-panel data processing and plotting is carried out using <code>panel</code> . However, these steps can be handled by separate functions if these are supplied as <code>plot.panel</code> and <code>process.panel</code> .
<code>scheme</code>	(character or list) The default coloring scheme for the plot. See Note below.
<code>lattice.like</code> , <code>plot</code> , <code>process</code> , <code>loa.settings</code>	(Various) Plot management elements. These can typically be ignored by most users, but allow plot developers to fine-tune plots. See Details below.
<code>speed</code> , <code>accel</code>	(Various) For <code>WatsonPlot</code> . The <code>x</code> and <code>y</code> terms, speed and acceleration, respectively, for a <code>Watson</code> plot.
<code>ref.line</code>	(Logical or list) For <code>WatsonPlot</code> . This argument manages the <code>speed = 0</code> reference added to <code>WatsonPlots</code> . It can be either a logical (<code>TRUE/FALSE</code>), to turn the line on or off, or a list of parameters to set the properties of the line.
<code>omit.stopped</code>	(Logical or character) For <code>WatsonPlot</code> . How to handle idling data: <code>FALSE</code> include in plot; <code>TRUE</code> or <code>'points'</code> removes idle points before plotting; <code>'cell'</code> or <code>cells</code> removes any cells that include idling points before plotting.
<code>plot.type</code>	(numeric) For <code>WatsonPlot</code> . Pre-set plot types: 1 scatter plot; 2 bin plot; 3 contour plot of binned data; 4 smoothed surface of binned data. See also <code>statistic</code>
<code>greyscale</code>	(Logical) For older plots. Should the plot be greyscale by default? This option resets the <code>lattice</code> color themes to greyscale while the plot is being generated. So: (1) This only effects the plot itself, not subsequent plots; and, (2) any user resets overwrite this, e.g. <code>latticePlot(..., greyscale=TRUE, col="red")</code> will place red symbols on an otherwise greyscale plot. Newer plots use the alternative <code>plot(..., scheme = "greyscale")</code> .
<code>grid</code>	(List) If supplied, a list of plot parameters to be used to control the appearance of the grid component of the plot. See Below.
<code>statistic</code>	(Function) when binning data with <code>XYZPlot</code> and <code>WatsonPlot</code> , the function to use when evaluating the elements of each data bin. By default, <code>length</code> is used if <code>z</code> is not supplied to generate a frequency plot and <code>mean</code> is used if <code>z</code> is supplied to generate a bin average plot.

<code>model</code>	(<code>pems.object</code>) The pems object to be used as a data source when plotting using <code>ggplot2</code> code. See below.
<code>x.res</code> , <code>y.res</code>	(Numerics) when binning data with <code>XYZPlot</code> , the number of x- and y-axis bins to generate.

Details

`pems.utils` includes conventional plot methods for `pems` and `pems.element` objects.

However, it also includes a range of higher level plotting functions developed using the `lattice` and `loa` packages.

Early plots, e.g. `latticePlot`, only allowed plot arguments using the `lattice` formula format. While this is flexible and very powerful system, some users preferred the more conventional `plot(x,y,...)` call format. So, newer plots, e.g. `pemsPlot`, allow both conventional plot and `lattice`-style formula calls.

`pemsXYZCondUnitsHandler` handles the two plot call styles by converting conventional plot calls to formula-based calls. It is typically included in a function like `pemsPlot` at an early stage. After it is run, the returned `x` can be treated as a formula and `y`, `z` and `cond` can be ignored. This routine is included as a discrete function within this package and others are welcome to use elsewhere for similar purposes. `edit(pemsPlot)` to see it.

Newer plots also use a combination of `lattice` and `loa` functions to provide a range of additional plotting options, such as integrated panel and key management. See `loa` documentation for further details.

`preprocess...` and `panel...` functions handle pre-plot and in-plot elements of plot generation. These use the `loa` modification of the `lattice` plotting framework.

See Notes and Examples.

The `fortify` method was developed by Hadley Wickham to simplify the integration of `ggplot2` functions and special object classes. It is a really nice idea for multiple reasons, the main one being that package users will probably never have to worry about it. However, having it means you can use a `pems` object directly as the data argument with `ggplot2` code.

Value

`pemsPlot` generates a bubble plot, so it plots (x,y) points, and by default color-grades and size-scales them according to `z`.

If supplied `speed` and `accel` as `x` and `y` cases, the `WatsonPlot` generates various forms of Watson's classic speed/accel frequency distribution plot.

`latticePlot` and `XYZPlot` are general purpose 'xy' and 'xyz' data plotting functions.

`fortify` is intended for used with `ggplot2` code when both `pems.utils` and `ggplot2` are loaded.

Warning

IMPORTANT: Conditioning is currently disabled on `XYZPlot`.

`XYZPlot` is a short-term replace for previous function `quickPlot`. It will most likely be replaced when `pems.utils.0.3` is released.

`pemsPlot` and `WatsonPlot` no longer accept formula `x`, `y`, `z` inputs.

With all these functions I have tried to make the default plotting options as robust as possible. However, it is not always possible to test all the plot combines that users might try. So, please let me know if anything is not working nicely for you. Thanks.

Note

General, other arguments:

Like most other plot functions in R, `lattice` functions use a number of common parameter terms. For example, `xlab` and `ylab` reset the x and y labels of a graph; `xlim` and `ylim` set the x- and y-scales of a graph; `col` sets the color of a plot element; `type` sets the type ('p' for points, 'l' for lines, etc); `pch` and `cex` set plot symbol type and size, respectively; and, `lty` and `lwd` set plot line type and thickness, respectively; etc. These terms are passed onto and evaluated by all these plot functions to provide standard plot control.

`latticePlot`:

The default plot option for `latticePlot` is `xyplot`.

panel options for `latticePlot`: Default `panel.xyplot`. The alternative panel, `panel.PEMSXYPlot` supplied as part of this package, adds a grid layer to a standard xy panel. It is simply made using two panels, `panel.grid` and `panel.xyplot`, both in `lattice`. `edit{panel.PEMSXYPlot}` to have a look at it. The extra code just allows you to pass specific plot parameters to the grid panel using the argument `grid`. You can build almost any plot layout using these and other panels in `lattice` as building blocks.

`XYZPlot`:

The default plot option for `latticePlot` is `levelplot`.

`pemsPlot`:

`pemsPlot` and subsequent plot functions use an alternative convention. Here, `plot` is a logical, which is used with another logical, `process`, to tell the plot function that data processing and plotting steps need to be handled separately. This option is particularly useful if a calculation is carried in-plot panel that affects the plot appearance and this needs to be integrated with other panels and keys. The handling mechanism is part of the `loa` package.

The reason for `latticePlot`, etc:

`latticePlot` combines a number of `lattice` and `latticeExtra` functions modifications I regularly use when plotting data. So, it is basically a short cut to save having to write out a lot of code I regularly use. I would encourage anyone to at the very least have a look at `lattice`. I also hope those learning `lattice`, find these functions a helpful introduction and handy 'stop gap' while they are getting to grips with the code behind `trellis` and `panel` structures.

Author(s)

Karl Ropkins

References

`lattice`:

Sarkar, Deepayan (2008) *Lattice: Multivariate Data Visualization with R*. Springer, New York. ISBN 978-0-387-75968-5

latticeExtra:

Deepayan Sarkar and Felix Andrews (2011). latticeExtra: Extra Graphical Utilities Based on Lattice. R package version 0.6-18. <http://CRAN.R-project.org/package=latticeExtra>

`lattice` is one of number of really nice graphical tools in R. Others, like `ggplot2` and `iplot`, help you to very quickly explore your data. But, for me the trellis framework of `lattice` has always been the most flexible.

`ggplot2`:

H. Wickham. `ggplot2`: elegant graphics for data analysis. Springer New York, 2009.

(See Chapter 9, section 9.3, pages 169-175, for discussion of `fortify`.)

See Also

See `lattice`, `latticeExtra`, `loa`.

Examples

```
#####
##example 1
#####

## Not run:
#plotting pems with other packages

#base
plot(pems.1)
plot(pems.1$velocity)

#lattice
xyplot(velocity~local.time, data = pems.1, type = "l")

#in ggplot2

#Note: Suggests only so you need to load this...
#Note: this uses fortify.pems

require(ggplot2)
qplot(time.stamp, velocity, data=pems.1)
ggplot(pems.1, aes(x = time.stamp, y = velocity)) + geom_line()
#etc

## End(Not run)

#####
##example 2
#####

#basic usage of latticePlot
```

```
latticePlot(velocity~local.time, data = pems.1, type = "l")

latticePlot(velocity~local.time, data = pems.1, col = "red",
            pch = 20, panel = panel.PEMSXYPlot,
            grid = list(col = "black", lty=2))

#####
##example 3
#####

#basic usage of XYZPlot

a <- calcAccel(velocity, local.time, data = pems.1, output="pems")

XYZPlot(~accel*velocity, data=a)

XYZPlot(~accel*velocity, data=a, plot = wireframe, shade=TRUE)

#####
##example 4
#####

#basic usage of pemsPlot

pemsPlot(local.time, velocity, data=pems.1, type="l")

#####
##example 5
#####

#basic usage of WatsonPlot

#Note: using 'a' generated in example 3
WatsonPlot(velocity, accel, data=a)

## Not run:
#omit.stopped for different handling of idling data
WatsonPlot(velocity, accel, data=a, omit.stopped="points")
WatsonPlot(velocity, accel, data=a, omit.stopped="cells")

#plot.type for different plot methods
WatsonPlot(velocity, accel, data=a, plot.type=1)
WatsonPlot(velocity, accel, data=a, plot.type=2)
WatsonPlot(velocity, accel, data=a, plot.type=3)
WatsonPlot(velocity, accel, data=a, plot.type=4)

## End(Not run)
```

4.1.example.data *example data for use with pems.utils*

Description

Example data intended for use with functions in `pems.utils`.

Usage

`pems.1`

Format

`pems.1` is a example pems object.

Details

`pems.1` is supplied as part of the `pems.utils` package.

Note

None at present

Source

Reference in preparation

References

None at present

See Also

See examples in [pems.structure](#).

4.2.look-up.tables *reference data for use with pems.utils*

Description

Various reference and example datasets intended for use with functions in `pems.utils`.

Usage

`ref.unit.conversions`

`ref.chem`

`ref.petrol`

`ref.diesel`

`pems.scheme`

Format

`ref.unit.conversions`: Unit conversion methods stored as a list of lists. See Details.

`ref.chem`, `ref.petrol`, `ref.diesel`: Common chemical and fuel constants stored as lists.

`pems.scheme`: Default scheme for `pems.utils` plots.

Details

`unit.conversions` is basically a 'look-up' for unit conversion methods. Each element of the list is another list. These lists are each individual conversion methods comprising four elements: `to` and `from`, character vectors given the unit ids and alias of the unit types that can be converted using the method; `conversion`, a function for the associated conversion method; and (possibly) `tag`, a more detailed description of the conversion intended for use in documentation.

Other `ref...` are sets of constants or reference information stored as lists. `ref.chem` contains atomic weights of some elements and molecular weights of some species. `ref.petrol` and `ref.diesel` contain default properties for typical fuels.

Note

`ref.unit.conversions` can be updated locally. See [convertUnits](#), [addUnitConversion](#), etc.

Examples

```
#basic structure
ref.unit.conversions[[1]]
```

 5.1.1.common.check.functions

common check... functions

Description

Various pems.utils workhorse functions for input checking and routine data handling.

Usage

```
checkOption(option=NULL, allowed.options=NULL,
            option.name = "option", allowed.options.name = "allowed.options",
            partial.match=TRUE, fun.name = "checkOption",
            if.missing = c("stop", "warning", "return"),
            output = c("option", "test.result"), ...)
```

```
checkPEMS(data = NULL, fun.name = "checkPEMS",
          if.missing = c("return", "warning", "stop"),
          output = c("pems", "data.frame", "test.result"),
          ...)
```

```
checkUnits(input = NULL, units = NULL, data = NULL,
           input.name = NULL, fun.name = "checkUnits",
           if.missing = c("stop", "warning", "return"),
           output = c("special", "units", "input", "test.result"),
           ..., unit.conversions = NULL)
```

```
checkOutput(input = NULL, data = NULL,
            input.name = NULL, fun.name = "checkOutput",
            if.missing = c("stop", "warning", "return"),
            output = c("pems", "data.frame", "input", "test.result"),
            overwrite = FALSE, ...)
```

```
checkIfMissing(..., if.missing = c("stop", "warning", "return"),
               reply = NULL, suggest = NULL, if.warning = NULL,
               fun.name = NULL)
```

Arguments

input	(vector, object or object element) An input to be tested or recovered for subsequent use by another function, e.g. a speed measurement from a pems object.
data	(data.frame, pems object) If supplied, the assumed source for an input. This can currently be a standard data.frame or a 'pems' object. Note: if an input is not found in data, the parent environment is then also checked before returning an error message.

<code>input.name, option.name</code>	(Optional character vectors) If a <code>check...</code> function is used as a workhorse by another function, the name it is given in any associated error messaging. See Note below.
<code>fun.name</code>	(Optional character vector) If a <code>check...</code> function is used as a workhorse routine within another function, the name of that other function to be used in any associated error messaging. See Note below.
<code>if.missing</code>	(Optional character vector) How to handle an input, option, etc, if missing, not supplied or NULL. Current options include: "stop" to stop the <code>check...</code> function and any parent function using it with an error message; "warning" to warn users that expected information was missing but to continue running the parent code; or "return" to continue running the parent code without any warnings.
<code>output</code>	(Character vector) Output mode for <code>check...</code> function results. Options typically include the <code>check_type</code> and "test.results". See Value below.
<code>...</code>	(Optional) Other arguments, currently ignored by all <code>check...</code> functions expect <code>checkIfMissing</code> .
<code>option, allowed.options, allowed.options.name</code>	(Character vectors) For <code>checkOption</code> , <code>option</code> and <code>allowed.options</code> are the supplied option, and the allowed options it should be one of, respectively, and <code>allowed.options.name</code> if way these allowed options should be identified in any associated error messaging. See Note below.
<code>partial.match</code>	(Logical) For <code>checkOption</code> , should partial matching be used when comparing <code>option</code> and <code>allowed.options</code> .
<code>units</code>	(Character vector) For <code>checkUnits</code> , the units to return input in, if requested (<code>output = "input"</code>). Note: The default, <code>output = "special"</code> , is a special case which allows <code>checkUnits</code> to return either the units if they are not set in the call (equivalent to <code>output = "units"</code>) or the input in the requested units if they are set in the call (equivalent to <code>output = "input"</code>).
<code>unit.conversions</code>	(List) For <code>checkUnits</code> , the conversion method source. See ref.unit.conversions and convertUnits for further details.
<code>overwrite</code>	(Logical) For <code>checkOutput</code> , when packing/repacking a <code>data.frame</code> or <code>pems</code> object, should 'same name' cases be overwritten? If FALSE and 'same names' are encountered, e.g. when modifying an existing <code>data.frame</code> or <code>pems</code> element, a new element if generated with a unique name in the form <code>[name].[number]</code> .
<code>reply, suggest, if.warning</code>	(Character vectors) For <code>checkIfMissing</code> , when generating error or warning messages, the main reply/problem description, any suggestions what users can try to fix this, and the action taken by the function if just warning (e.g. setting the missing value to NULL), respectively. All are options.

Details

The `check...` functions are intended as a means of future-proofing `pems.utils` data handling. They provide routine error/warning messaging and consistent 'front-of-house' handling of function arguments regardless of any underlying changes in the structure of the `pems` objects and/or

`pems.utils` code. This means third-party function developed using these functions should be highly stable.

`checkOption` checks a supplied option against a set of allowed options, and then if present or matchable returns the assigned option. It is intended as a workhorse for handling optional function arguments.

`checkPEMS` checks a supplied data source and provides a short-cut for converting this to and from `data.frames` and `pems` object classes. It is intended as a 'best-of-both-worlds' mechanism, so users can supply data in various different formats, but function developers only have to work with that data in one (known) format.

`checkUnits` checks the units of a previously recovered input, and then, depending on the output setting, returns either the units of the input or the input in the required units (assuming the associated conversion is known).

`checkOutput` packs/repacks a previously recovered input. Depending on the output setting, this can be as the (standalone) input, an element of a `data.frame` or an element of a `pems` object.

`checkIfMissing` if a workhorse function for the `if.missing` argument. If any of the supplied additional arguments are NULL, it stops, warns and continues or continues a parent function according to the `if.missing` argument. If supplied, `reply`, `suggest` and `if.warning` arguments are used to generate the associated error or warning message.

Value

All `check...` functions return a logical if `output = "test.result"`, TRUE if the input, option, etc., is suitable for use in that fashion or FALSE if not.

Otherwise,

`checkOption` return the `option` argument if valid (on the basis of `if.missing`) or an error, warning and/or NULL (on the basis of `if.missing`) if not. If `partial.match = TRUE` and partial matching is possible this is in the full form given in `allowed.options` regardless of the degree of abbreviation used by the user.

`checkPEMS` returns the `data` argument if valid or an error, warning and/or NULL (on the basis of `if.missing`) if not. Depending on output setting, the valid return is either a `data.frame` or `pems` object.

`checkUnits` returns the units of the input argument if no other information is supplied and units have previously been assigned to that input. If units are assigned in the call or output is forced (`output = "input"`), the input is returned in the requested units. If this action is not possible (e.g. `pems.utils` does not know the conversion), the function returns an error, a warning and the unchanged input or the unchanged input alone depending on `if.missing` setting.

Depening on `if.missing` argument, `checkIfMissing` either stops all parent functions with an error message, warns of a problem but allows parent functions to continue running, or allows parent functions to continue without informing the user.

Note

The `...name` arguments allow the `check...` functions to be used silently. If a parent function is identified as `fun.name` and the check case (`codeinput`, `option`, etc.) is identified with the associated `...name` argument these are used in any associated error messaging.

Author(s)

Karl Ropkins

References

[TO DO]

See AlsoSee [ref.unit.conversions](#) and [convertUnits](#) for general unit handling.

 5.1.2.corrections *Corrections*

Description

Corrections are a special subset of functions which by default write over the elements that they recalculate.

Usage

```
correctInput(input = NULL, ..., data = NULL,
             correction = NULL)
```

```
zeroNegatives(input = NULL, ..., data = NULL,
              screen = FALSE)
```

```
correctBaseline(x, ..., data = NULL, output = "ans")
```

```
#associated
```

```
calcPack2(input, ..., settings = NULL, data = NULL)
```

Arguments

input	(Required data series typically vectors) The input to use when makin a correc-tion. This is typically a vector or element in either a <code>data.frame</code> or <code>pems</code> object.
x	(For <code>correctBaseline</code>) (Required data series typically vectors) The input to use when makin a correction. This is typically a vector or element in either a <code>data.frame</code> or <code>pems</code> object.
...	(Optional) Other arguments, typically passed on.
data	(Optional <code>data.frame</code> or <code>pems</code> object) The data source if either a <code>data.frame</code> or <code>pems</code> object is being used.

correction	(For correctInput, required function) The correction operation to apply to input. This is typically a function or function name (as character string).
screen	(For zeroNegatives, logical) If the user intends screening the correction before applying it, this should be set to TRUE.
output	(character) Where options exists for the function output, the required output. For correctBaseline, current options: 'ans' (the default) and 'diagnostic'.
settings	(For calcPack2, list) Any arguments to be used as settings when handling pems.elements. Unless developing functions, this can typically be ignored.

Details

correctInput is a general correction handlers. It accepts an input and a function, correction, which it applies to input.

zeroNegatives resets any negative values in an input to zero.

correctBaseline attempts to correct the baseline of a supplied data (pems.element vector) time-series. Baseline corrections are carried out using methods from the [baseline](#) package. See Below.

calcPack2 is an alternative version of [calcPack](#). See associated help for details.

Value

With the exception of calcPack2, all the above functions generate input corrections.

correctBaseline returns the supplied data time-series (x) after applying the requested baseline correction (see below).

Note

By default, corrections return results in the format of the input. So: If inputs are supplied as vectors, the answer is returned as a vector; If inputs are supplied in a pems object, that pems object is returned with the answer added in. This behaviour is enabled by the default output = "special". Output type can be forced by declaring output in the function call. Options "input", "data.frame" and "pems" return vectors, data.frames and pems objects, respectively.

Unlike other calculations, corrections automatically replace the associated input, unless prevented (using overwrite = FALSE).

This function management is handled by [calcChecks](#) and [calcPack](#). These are front and back end calc... function add-ins that anyone can use as a 'minimal code' means of integrating third-party and pems.utils functions.

See [calcChecks](#) documentation for details.

correctBaseline is a recent transfer from sleeper.service. It uses [baseline](#) functions to provide 'best guess' baseline corrections.

By default, it applies:

```
baseline(..., method="rollingBall", wm=50, ws=50)
```

Please Note the 'best guess': As baseline corrections are based statistical estimates of likely baselines rather than actual measures of drift these should be treated as estimates.

Unit management is by [convertUnits](#). See associated help documentation for details.

Author(s)

Karl Ropkins

References

baseline:

Kristian Hovde Liland and Bjorn-Helge Mevik (2015). baseline: Baseline Correction of Spectra. R package version 1.2-1. <https://CRAN.R-project.org/package=baseline>

See Also

[baseline](#) regarding baseline corrections.

[common.calculations](#), [calcVSP](#) or [calcEm](#) for calculation functions.

[getElement](#) ([checkUnits](#), etc and [convertUnits](#) for data management.

Examples

```
#####  
##example 1  
#####  
  
#basic usage  
  
zeroNegatives(-10:10) #etc
```

5.2.pems.tidyverse.tools

Functions to use tidyverse code with pems.utils outputs

Description

Various codes and methods.

Usage

```
#pems object methods  
  
#dplyr (1) standard methods  
## S3 method for class 'pems'  
select(.data, ...)  
## S3 method for class 'pems'  
rename(.data, ...)
```

```
## S3 method for class 'pems'  
filter(.data, ...)  
## S3 method for class 'pems'  
arrange(.data, ...)  
## S3 method for class 'pems'  
slice(.data, ...)  
## S3 method for class 'pems'  
mutate(.data, ..., units=NULL, warn=TRUE)  
## S3 method for class 'pems'  
group_by(.data, ..., add=FALSE)  
## S3 method for class 'pems'  
groups(x)  
## S3 method for class 'pems'  
ungroup(x, ...)  
## S3 method for class 'pems'  
group_size(x)  
## S3 method for class 'pems'  
n_groups(x)  
## S3 method for class 'pems'  
summarise(.data, ...)  
## S3 method for class 'pems'  
pull(.data, ...)  
  
#dplyr (2) related underscore methods  
## S3 method for class 'pems'  
select_(.data, ..., warn=TRUE)  
## S3 method for class 'pems'  
rename_(.data, ..., warn=TRUE)  
## S3 method for class 'pems'  
filter_(.data, ..., warn=TRUE)  
## S3 method for class 'pems'  
arrange_(.data, ..., warn=TRUE)  
## S3 method for class 'pems'  
slice_(.data, ..., warn=TRUE)  
## S3 method for class 'pems'  
mutate_(.data, ..., units=NULL, warn=TRUE)  
## S3 method for class 'pems'  
group_by_(.data, ..., add=FALSE, warn=TRUE)  
## S3 method for class 'pems'  
summarise_(.data, ..., warn=TRUE)  
  
#dplyr (3) joining methods  
## S3 method for class 'pems'  
inner_join(x, y, by = NULL, copy = FALSE, ...)  
## S3 method for class 'pems'  
left_join(x, y, by = NULL, copy = FALSE, ...)  
## S3 method for class 'pems'  
right_join(x, y, by = NULL, copy = FALSE, ...)
```

```
## S3 method for class 'pems'
full_join(x, y, by = NULL, copy = FALSE, ...)
## S3 method for class 'pems'
semi_join(x, y, by = NULL, copy = FALSE, ...)
## S3 method for class 'pems'
anti_join(x, y, by = NULL, copy = FALSE, ...)
```

Arguments

<code>.data</code>	(pems.object) The pems object to be used with, e.g. dplyr code.
<code>...</code>	(Optional) Other arguments, currently all passed on to equivalent tidyverse function or method.
<code>warn</code>	(Optional) Give warnings? For an underscore methods: a warning that an underscore method was used (See Below). For mutate: if new elements are generated within unit assignments.
<code>units</code>	(Character) In mutate, the units to assign to new elements created by call. See Below.
<code>x</code>	(Various) For group... functions, an object of grouped_df class. For ...join functions, the first of two datasets, typically a pems object or data.frame, to be joined together.
<code>add</code>	(Optional) Argument used by group_by and related dplyr grouping functions.
<code>y, by, copy</code>	(various) For ...join functions, consistent with dplyr, y is the second of two datasets, typically a pems object or data.frame, to be joined together, the first being x, and by and copy are optional arguments. See below.

Details

The pems object methods `select`, `rename`, `filter`, `arrange`, `slice`, `mutate`, `group_by` and `summarise` are similar to `data.frame` methods of the same names in dplyr, but (hopefully) they also track units, etc, like a pems object. Work in progress. See below, especially Note.

Equivalent underscore methods (`select_`, etc) are also provided, although it should be noted that their future in dplyr itself is not certain.

Data joining methods include `inner_join`, `left_join`, `right_join`, `full_join`, `semi_join` and `anti_join`. Like above these are similar `data.frame` equivalents in dplyr, but (hopefully) also track units, etc, like a pems object. Same 'work in progress' caveat. See below.

Value

`select` returns the requested part of the supplied pems object, e.g.: `select(pems.1, velocity)` returns the velocity element of pems.1 as a single column pems.object, consistent with the `data.frame` handling of `select.data.frame`.

`rename` returns the supplied pems object with the requested name change, e.g.: `rename(pems.1, speed=velocity)` returns pems.1 with the velocity column renamed speed.

`filter` returns the supplied pems object after the requested filter operation, e.g.: `filter(pems.1, velocity>0.5)` returns pems.1 after excluding all rows where the velocity value was less than or equal to 0.5.

arrange returns the supplied pems object reordered based on order of values in an identified element, e.g.: `arrange(pems.1, velocity)` returns pems.1 with its row reordered lowest to highest velocity entry.

slice returns requested rows of the supplied pems object, e.g.: `slice(pems.1, 1:10)` returns rows 1 to 10 of pems.1 as a new pems object.

mutate returns the supplied pems object with extra elements calculated as requested, e.g.: `mutate(pems.1, new=velocity*` returns the pems object with additional column, called new, which is twice the values in the velocity column. The units of the new column can be set using the additional argument units, e.g. `mutate(pems.1, new=velocity*2, units="ick")`.

group_by returns a grouped_df object. [to document]

summarise [to document]

The `..._join` joining methods, join to supplied datasets. The first, x, must be a pems to employ `..._join.pems` by the second, y can be e.g. a data.frame, etc. [rest to document... link to dplyr and vignette]

Warning

This currently work in progress - handle with care.

Note

Currently not sure what I think about tidyverse, but it is always interesting, and ideas like fortify are really nice.

Author(s)

Karl Ropkins

References

Generics in general:

H. Wickham. Advanced R. CRC Press, 2014.

(Not yet fully implemented within this package.)

ggplot2:

H. Wickham. ggplot2: elegant graphics for data analysis. Springer New York, 2009.

(See Chapter 9, section 9.3, pages 169-175, for discussion of fortify)

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